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Engineering Report

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ENVIRONMENT
Water Resources Management Services
Dam Safety Branch

92-00073/

REPORT ON THE
COUGAR CREEK DAM
FAILURE

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February 1991
Dam Safety Branch

COUGAR CREEK DAM FAILURE

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"REPORT ON THE FAILURE OF COUGAR CREEK DAM"

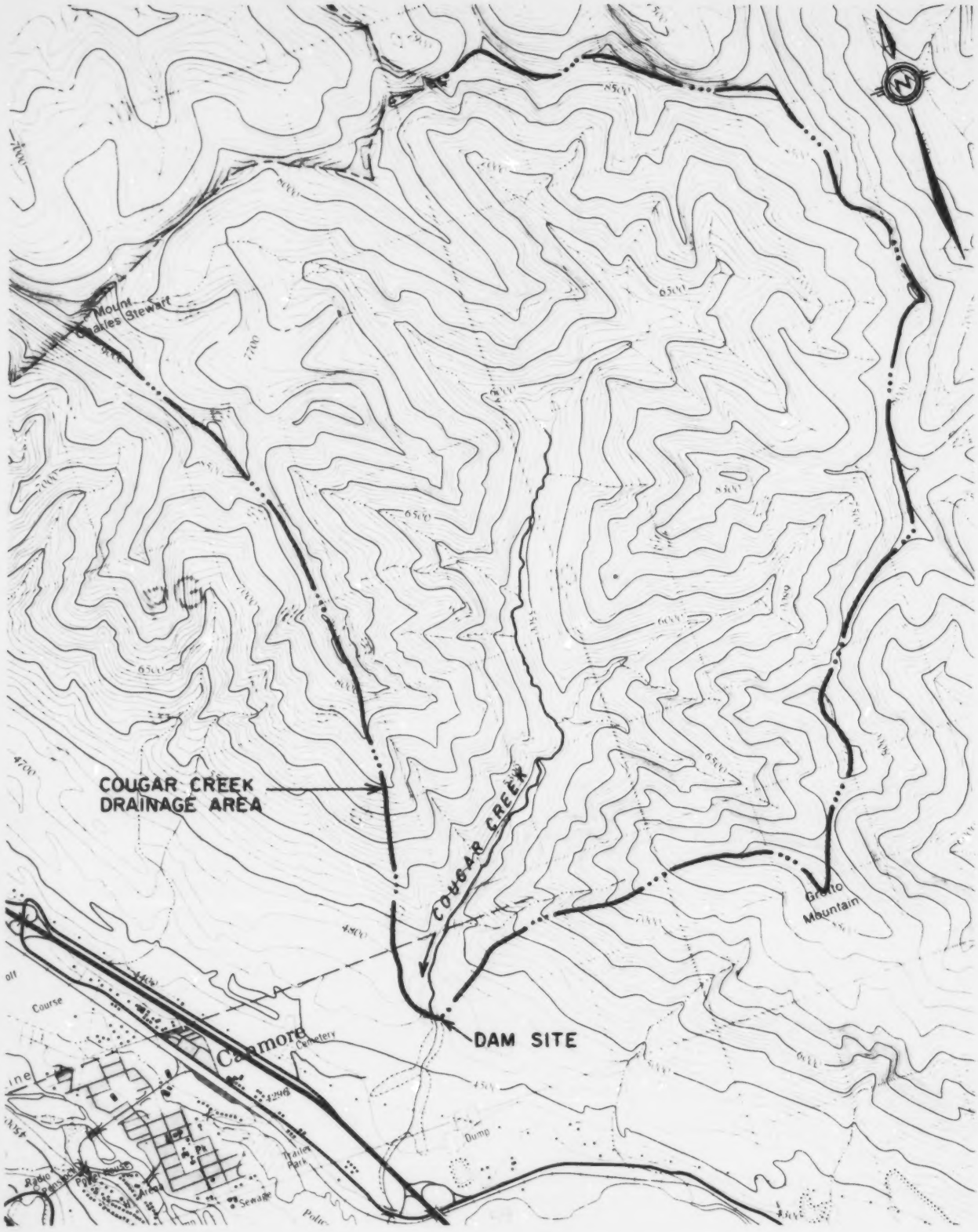
INTRODUCTION

Cougar Creek Dam, located in NW 34-24-20-5, was constructed in 1982 as part of a residential/industrial subdivision development at the Town of Canmore. The project consisted of a sediment trap with downstream channel armouring to limit bank erosion in the downstream alluvial fan on which the proposed subdivision was to be built. Since the construction of these works, a large residential housing subdivision has been developed on the right bank area, approximately 1.0 kilometre downstream.

The dam, which is licenced to the Town of Canmore, was designed by Hydrocon Engineering (Continental) Ltd. for Engineering Canada Associates Ltd., consultants to Alberta Housing Corporation. Approximately 10.4 metres in height and 47 metres in width, the dam was designed as a coarse rock overflow sediment trap with a storage capacity of approximately 35,000 cubic metres. The structure was to be pervious enough to prevent permanent ponding in the reservoir and be able to withstand overtopping by a 1:100 year event, with 0.67 metres of water over the crest.

Further details on the design are available from a paper presented to the 1982 Annual Conference of the Canadian Society for Civil Engineers in Edmonton, Alberta, May 27-18, 1982. The paper entitled "Channel Stabilization on an Alluvial Fan Near Canmore," was presented by G.R.E. Beckstead, P. Eng., Senior Engineer, Hydrocon Engineering (Continental) Ltd.

At approximately 5:20 p.m. on May 25, 1990, Cougar Creek Dam overtopped and breached. This report gives details of the events leading up to the failure and suggests possible causes.



Alberta ENVIRONMENT		COUGAR CREEK DAM	
		LOCATION PLAN N.W. 34-24-10-5	
SUBMITTED DATE	DESIGNED CHECKED		
APPROVED DATE	DRAWN CHECKED	SCALE 1:50 000 DATE OCT. 1990	SHEET 1 OF FILE No. 15284

FILE No. DRAWING No. MICROFILM DATE

HYDROLOGY

Data provided by Alberta Transportation, Bridge Branch was used by the consultant to determine the flood frequencies for the 47 square kilometre Cougar Creek drainage basin. The flood frequency distribution determined by Hydrocon is as follows:

Period Return	Discharge (m^3/s) Mean Daily	Instantaneous
100	18.7	30.8
50	16.7	23.7
25	14.4	18.3
10	11.6	12.1

No reliable data is available for the Cougar Creek Drainage Basin on the rainfall and inflows which immediately preceded the failure. However, Mr. George Field, an Alpine Specialist with the Operations Branch of Kananaskis Country, Department of Recreation & Parks, has provided us with precipitation data for Banff as well as some insight as to the source of the inflows. (This correspondence can be found in the Appendix).

The following precipitation data is from the Banff Weather Station which is located approximately 20.0 kilometres northwest of Canmore.

Precipitation Data

May 15, 1990 - 1.4 mm
May 16, 1990 - 0.0 mm
May 17, 1990 - 0.2 mm
May 18, 1990 - 3.8 mm
May 19, 1990 - 1.0 mm
May 20, 1990 - 5.6 mm
May 21, 1990 - 0.2 mm
May 22, 1990 - 0.0 mm
May 23, 1990 - Trace
May 24, 1990 - 21.8 mm
May 25, 1990 - 29.6 mm*

*The day the sediment trap failed.

In addition to the precipitation, snowpillow data (see Appendix) applicable to the area indicate that rapid snowmelt was occurring at the same time at higher elevations (over 2000 metres). Witnesses at the dam site indicate the reservoir rose 1.0 metre (to the crest) in the hour before the failure and only 0.15 metres in the hour previous to that. Based on this rapid change in reservoir elevation and downstream flows, our estimate of the inflow is approximately 13 cubic metres per second. This represents an average inflow for the one hour preceding the failure.

From photos No. 9069-C6 and No. 9069-B27, (see Appendix) taken 45 minutes and 2 hours respectively after the failure, it can be seen that there is still a significant amount of water flowing in Cougar Creek upstream of the sediment trap. Furthermore, the depth of flow is approximately the same in both cases. From the above observations, it would be reasonable to assume then that the peak flows coincided with the time of the sediment trap failure. The substantial increase in the inflows from the hour previous to and subsequent to the failure can be attributed to a number of sources, but the most likely being that of either: 1) the accelerated melting of the 1.0 metre snow pack due to warm weather and rainfall; or 2) an avalanche in the upper reaches of the drainage basin (see Appendix).

The Cougar Creek Sediment Trap was designed essentially as a coarse rock overflow dam, pervious enough to prevent ponding (long term) in the reservoir and safely withstand the design overtopping of a 1:100 year event equivalent to 0.67 metres above crest elevation. There is no data available to ascertain the stage/discharge relationship (flow through rate

at various heads) of the dam nor is there an historical record of previous flow-through rates but it is reasonable to assume that under normal low flow conditions, the outflow was equal to the inflow, i.e. ponding did not take place. This was achieved by a coarse rock (Class II) drain through the foundation of the dam along the original water course.

It was anticipated that the sediment trap would prevent the downstream movement of river gravels and necessitate their periodic removal when accumulation levels warranted. Canmore Town Manager, Mr. Frank Kosa, indicated that there had never been the need to "clean out" the sediment trap since its construction in 1982. He stated that the sediment trap was normally inspected three or four times a year and also after any high flows in Cougar Creek caused by rainfall or snowmelt. The remaining gravel terraces immediately upstream of the sediment trap indicate that there was a negligible amount of gravel accumulation over the operational life of the sediment trap.

From our inspection of the failed dam on August 14, 1990, it would appear that the sediment trap had diminished pervious qualities at the time of its failure, due to silting of the upstream slope. However, the rock-filled channel drain which ran through the foundation of the dam along the original water course did not appear to have been clogged, as evidenced by the outflow of water from the downstream toe of the sediment trap prior to its failure. Unfortunately, we cannot determine whether the channel drain was operating optimally or if, in fact, its flows were impeded by the silt and, if so, to what degree. We observed that the

upstream slopes on both remaining abutments were covered with a layer of silt which extended from the reservoir bed up the slopes and to within 1.5 metres of the crest. This silt layer averaged 0.3 metres in thickness over the slopes with some areas 0.6 metres deep. If this silt layer covered the entire upstream slope and adjoining reservoir bed, it could have formed an impervious layer impeding flows through the dam or the rock filled channel drain. If this is the case, it would have resulted in water ponding considerably faster than might otherwise have occurred. A sample of this silt was taken and analysis (see Appendix) indicated it to be 75% silt, with the remaining 25% smaller than the #0.4 metric sieve.

It is possible the flow velocities through the channel drain were sufficient to prevent deposition and blockage by the silt, but since all traces of the drain were washed away during the failure, it is not possible to determine its level of function and resulting impact, if any, on the subsequent overtopping and failure.

At least one previous event occurred during which a layer of silt was deposited in the reservoir, as evidenced by the exposed strata in the reservoir. (See photos No. 9069-B4 and No. 9048-10A). A sample of this silt was taken for analysis which showed it to be very similar to the silt covering the upstream slope (see Appendix).

DESIGN

The design as an overflow structure is unusual. It was meant to function as a normally non-pooling sediment trap of sufficient

permeability so that inflows could be safely passed through the structure and yet allow retention of the sediments. Therefore, a low level conduit could not be used without extensive filters over the inlet. To permit the passage of inflows it was decided to construct a rock filled channel drain along the original water course (see plan #15284-22 in the Appendix). The material specified for the channel drain was a Class II rock (see Material Size & Specifications - Plan #15284-22 in the Appendix). The drain was to be 1.0 metre deep, 4.0 metres wide and approximately 46.0 metres long. To protect the overlying unclassified rock core against erosional damage from operation of this drain, it was to be buffered by a 1.0 metre layer of Class III filter material (see Material Size & Specifications - Plan #15284-22 in the Appendix). The unclassified rock core of the sediment trap was specified as Class I "having less than 15% by weight smaller than 75 mm and shall have an average size of approximately 200 mm unless otherwise specified by the Engineer."

The Class I core material was to be covered evenly with 500 mm of Class III filter on its crest and both upstream and downstream slopes. The crest and the downstream slope were to receive a 1.0 metre layer of Class II riprap to provide protection during overtopping events. An apron of Class II riprap at the downstream toe was also provided for this purpose. The sediment trap as proposed on plan 15284-22 was to be approximately 7.8 metres high, approximately 38.0 metres wide, have a 3.5 metre crest width with a 1.5:1 upstream and 2.0:1 downstream slope.

An inspection for licensing purposes was carried out in May, 1982. It noted a number of modifications to the filed plans for the project:

- the top width was reduced to 2.0 - 2.5 metres
- an apron of Class II riprap 1.0 metre wide and 2.0 metres deep was constructed along the upstream toe
- the downstream toe apron was constructed of Class II riprap with a layer of Class III
- an access ramp had been constructed half way up the right downstream slope.

It should be noted that the design did not specify a filter under or on the sides of the channel; nor did it call for excavation at the base of the dam. It was intended that large flows would be handled by passage over the crest of the dam and by cascading down the downstream slope. The downstream slope was to be protected against erosional damage by a one metre layer of Class II rock on top of a 0.5 metre layer of Class III rock. The design was based on discharging the 1:100 year flood flows with the surcharge of 0.67 metres above crest elevation. The sediment trap had previously passed all inflow events prior to the May 1990 flood, but we do not know if any of these events resulted in overtopping.

SITE INSPECTION

The site was visited August 14, 1990 to examine the remnants of the sediment trap. Very little of the top of the right abutment remained but approximately 5 metres of the top of the left abutment was intact. The river bed was scoured to bedrock in the middle of the breach. The failure also removed any evidence of the Class II riprap channel drain which followed the original water course under the dam.

Upstream Slopes

The remaining upstream slopes were covered with a blanket of silt which extended from the reservoir to within 1.5 metres of the crest. If this silt blanket fully covered the entire upstream slope and extended to the adjoining reservoir bed, it is probable that any flow through was impeded causing increased ponding of the inflow until overtopping occurred. (See Appendix for the particle size analysis of this material and photo Nos. 9069-B-4 and 9014-4).

From what could be observed through the blanket of silt, a layer of Class II riprap-limestone blocks 1.0 - 1.5 metres in size were noted on the remaining slopes. It appeared to be more loosely placed than that on the downstream slope. The silt layer covering the upstream slopes had a small component of organic material throughout. On the upper reaches of the slopes a mat of logs and branches covered the silt layer.

Crest

The only remaining intact section of the crest was on the left abutment. The width of this crest section was approximately 1.5 - 2.0 metres. The 1.0 metre cover of Class II riprap on the crest was noted.

Downstream Slope

The remaining portion of the downstream slope on the left abutment is in very good condition considering what happened. The riprap blanket on the downstream slope is generally 2.0 metres thick. Most of the rock in this blanket tended to be in the lower end of the specification for Class II riprap.

Downstream Apron

The apron of the downstream toe consisting of Class II riprap was present. Hydraulic action has modified it somewhat but its general outlay can still be discerned. Due to alluvial deposition it was not possible to determine its depth or if its foundation had been excavated.

Abutments

Very little could be observed of the left abutment contact as it was still very much intact. The right abutment had experienced severe erosion at the time of failure and the abutment contact was exposed. There were large natural voids in the native rock abutment contact. Those voids were not filled with any core material and as a result could have permitted passage of inflows along the abutment contact. It is possible that any unclassified core material which may have been placed in these voids at the time of construction could have been removed by the May/90 flood or previous events. It cannot be determined what, if any, flow along the abutment contact occurred during the May/90 event. There was no evidence of Class III filter material buffering the abutment contact and the unclassified rock core material.

Core

The core material - Class I unclassified rock, was well exposed in the remaining left abutment section of the sediment trap. The specifications for the Class I core material are "Class I unclassified rock shall have less than 15% by weight smaller than

75 mm and shall have an average size of approximately 200 mm unless otherwise approved by the engineer." The core material we observed appeared to have a very high percentage of fines. Most of the larger rock had little if any point to point contact as it was separated by the finer material. A grab sample of fines from the core material showed it to be approximately 60% gravel, 25% sand and 15% silt (see Appendix). From site observations it appeared that the source material for the core was alluvial deposits obtained near the sediment trap. It was not possible to determine what, if any, pre-construction foundation preparation was performed. It is assumed from the channel drain specification that the Class I core material was placed directly over the existing river bed alluvial deposits. (The structure was not intended to be impervious). It was difficult to ascertain the presence of the 0.5 metre blanket of Class III filter material covering the Class I core material as was specified. A proper examination of the remaining left abutment section using a backhoe would clarify these points.

FAILURE

The Cougar Creek Dam (sediment trap) failed at 5:20 p.m., May 25, 1990. Witnesses at the site indicate that the reservoir rose 1.0 metre in the hour before the failure and 0.15 metres in the hour previous to that. While it is obvious that the inflow was increasing significantly, it cannot be determined exactly when it peaked or what the maximum peak flow was. It can only be assumed that the peak flow coincided with the time of the failure.

Alberta Environment staff who witnessed and photographed the failure provided the following details. Approximately one hour before the failure, water was exiting from half way up the downstream slope and across its entire width and cascading down, (see photo No. 9069-B20). The water seemed to be coming through and around the dam rather than under or over it. There is no indication as to whether the elevation of the water exiting the downstream slope increased with the rising reservoir in the hour preceding the failure. As the water level approached the crest, it began to flow through the Class II riprap armouring and cascaded down the downstream slope. At no time did the water flowing over the crest through the Class II riprap armouring, exceed the top elevation. The failure occurred shortly after the water began flowing through the crest armouring. For about 20 - 30 seconds before the failure onset, there was the distinctive sound of rocks "mashing or crashing." The failure began on the downstream edge of the crest, forming a "V" shaped breach which grew quickly, progressing downward to the bedrock underlaying the river bed. The entire failure and reservoir purging took only 3 minutes and resulted in a 3.0 metre flood wave moving downstream, according to Alberta Environment staff. For a list of chronological events leading up to the failure, see the Appendix.

Mr. Ingo Kalk, a professional photographer from Canmore, was on the site when the dam failed and was kind enough to give us permission to reproduce some of the pictures he took of the failure. Mr. Kalk apparently has a complete photographic record of the failure from onset to completion as well as some of the resulting damages. Mr. Kalk can be

reached at Photographic Impressions, P.O. Box 2079, Canmore, AB, TOL OMO, Phone (403) 678-2362. Murray Dale, a Television reporter with CFCN in Calgary, was also on the scene taking news footage of the sediment trap prior to the failure.

DAMAGE

The maximum possible volume of water impounded at the time of the failure is calculated at 35,000 cubic metres (35 dam^3). The figure is derived from the area/capacity curves as provided on Hydrocon plan #52-32.1-7 (our plan #15284-22) and assumes negligible accumulation of debris. However, there was some sediment in the reservoir but we are uncertain as to how much so an arbitrary figure of about 15 percent (based on gravel terraces observed during site visit) or approximately 5250 cubic metres has been assigned. Therefore, at the time of failure, approximately 29,750 cubic metres of water and an unknown volume of debris in the form of river cobbles and sandy gravels passed through the breach and flowed downstream.

The armoured channel immediately downstream of the dam experienced substantial erosion damage. Minor damage occurred to the Hwy #1 shoulders when the backed up flood waters overtopped the road. It was estimated by witnesses that the maximum depth of water across Hwy #1 was no more than 0.15 meters. The CP rail track located downstream of Hwy #1 received damage because the culverts under the tracks plugged completely with debris. As a result, water washed over the tracks, eroding ballast and rail bed material. Damage to the tracks was repaired within two hours of the occurrence. However, the track remained closed to rail

traffic until 9:00 a.m. the next morning while the culverts under the tracks were unplugged as there was concern that another rainstorm could have caused further damage to the tracks. The costs of repairs to the armoured channel and the sediment trap are unknown at this time.

POSSIBLE CAUSES OF THE FAILURE

There are a number of possibilities which either singularly or in combination could have led to the failure of the Cougar Creek Dam:

- piping failure of foundation contact or through the Class I core material;
- piping failure of the alluvial deposits underlaying the structure;
- instability of the Class I material due to steep side slopes;
- instability of the entire structure due to not being secured to the bedrock foundation or abutments;
- erosion failure of partially liquified core material during overtopping due to the incompatibility of riprap and core material.
- silt laden inflow could have prevented the normal outflow resulting in excessive inflow retention and overtopping (contributing factor only).
- instability caused by modifications to the structure during its construction - namely reduction of the crest width.

The most probable cause of failure based on observations provided by witnesses at the site is instability of the downstream slope induced by erosion of the underlaying Class I unclassified core material. Any removal or displacement of these materials would cause accompanying

movement or settlement of the Class II riprap armouring the downstream slope and precipitate instability in the riprap above it. Witnesses indicate that the crest armouring began failing at the downstream edge of the crest. The most likely scenario for the failure is: water flowing through the armoured crest and over the downstream slope eroded the underlaying Class I core material until enough material was displaced to allow the riprap above to settle creating a depression which allowed increased flow from the reservoir thus causing further erosion, leading to a complete breach. It is felt that the erosion of the Class I core material began at its upper downstream edge and progressed from there. This scenario does not eliminate other potential causes, or dampen their possible impact, it only suggests the most likely cause based on available information.

CONCLUSIONS

a) The dam failed before reaching its design overflow capacity of 0.67 metres.

b) The design, licencing and inspection of these types of structures requires careful consideration.

c) Even though this dam is classified as small, the potential for serious damage on failure exists.

d) The use of overflow structures of this design should be discouraged.

e) Other methods of sediment collection and storage should be investigated.

f) A condition of licencing any dam which falls under the **Dam and Canal Safety Regulation** should be the notification of the Dam Safety Branch of the intent to begin construction at least 14 days prior to the start.

Alberta MEMORANDUM

ENVIRONMENT

WATER RESOURCES MANAGEMENT SERVICES
TECHNICAL SERVICES DIVISION

FROM M. E. Quazi, P. Eng.
Branch Head
River Engineering Branch

OUR FILE REFERENCE 5B, Cougar Creek
90-0138

YOUR FILE REFERENCE

TO Distribution List

DATE May 29, 1990

TELEPHONE 427-6280

SUBJECT **Cougar Creek Dam Failure**

Enclosed for your information is a copy of the briefing notes assembled on the above subject.

These notes were put together very quickly, therefore, please advise if there are any errors or omissions.

T. H. Winhold, P. Eng.
(for) M. E. Quazi, P. Eng.

TW/tc

cc: R. K. Deeprose

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COUGAR CREEK DAM AND SEDIMENT TRAP

Background:

The Cougar Creek Dam was constructed in 1982 as part of a proposed residential/industrial subdivision development at Canmore. The subdivision is located on an alluvial fan adjacent to Cougar Creek just to the east of the main town site and the Trans Canada Highway.

During high flow periods Cougar Creek, like many mountain streams, is subject to severe sediment deposition and resulting dramatic channel shifting. The purpose of the dam was to act as a sediment trap and was located upstream of the subdivision developments near the apex of the alluvial fan. The dam structure, together with channelization and bank armouring along the creek were intended to stabilize the channel, thus providing protection against bank erosion and potential flooding.

The dam and associated engineering works were designed by Hydrocon Engineering (Continental) Ltd. of Calgary for Engineering Canada Associates Ltd., consultants to Alberta Housing Corporation. The project was reviewed by Alberta Environment and authorized on November 20, 1981. A Licence under the Water Resources Act was issued on March 21, 1984.

Structure Design:

The dam was designed as a "flow through" rock fill structure having a sediment storage capacity of approximately 65 acre - feet. It was designed to permit overflow and with stand failure during a 1:100 year flood. The height of the dam is approximately 9 metres.

Sequence of Events Leading to Failure of Dam on May 25 (information provided by Water Resources Administration Division, Calgary:

May 25, 1990	Kent Berg received a telephone call from Frank Kosa, Manager, Town of Canmore.
10:30 AM (approximately)	He is concerned about the dam on Cougar Creek (Water Rights file 15284) that was built by Alberta Housing. The dam is full of water and is 2/3 full of debris. He is also concerned about bank erosion. He said he has not seen Cougar Creek with this much water in it before in the 10 years he has been in Canmore. If the bank continues to erode, they may have a problem with flooding of some houses in the subdivision.

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Vern Head with Dam Safety was contacted and asked to comment. He reviewed the file and plans to determine if there is cause for major concern. He believes the dam is working as designed. In consultation with River Engineering, he indicated that they have no concern regarding stability of the structure. Should the dam be overtopped by debris, the concern is with the Highway 1 culverts downstream. Their advice is to notify Transportation should debris come down the creek.

This information was passed on to Frank Kosa by Kent Berg.

3:30 PM — Andre' Chaumont and Darwin Monita of W.R.A.D. Calgary arrived on site. CPR rail officials were informed of the presence of a dam upstream on Cougar Creek. Three backhoes were in the creek attempting to divert water away from the railway tracks.

4:15 PM — The dam site was inspected. The water level was approximately 1 metre from the top of the dam. Water was permeating the dam. A CPR employee on site informed us that this water level was approximately six inches higher than the level one hour prior.

4:30 PM — CPR officials at the track site were informed by regional staff that the water level was increasing and could possibly top the dam.

4:45 PM — Dwayne Manchak of W.R.A.D. Calgary was called and informed of the situation. He informed Al McMillan.

5:10 PM — The dam was reinspected. The water level had reached the top of the dam and was rising quickly. The water began flowing amongst the rocks at the very top of the dam and some debris previously held back, overtopped the dam. Some boulders slid down from the top of the dam. CPR officials were at the site.

5:20 PM — The dam began breaking away. CPR officials immediately radioed staff at the track crossing and ordered them to evacuate the creek area. The entire

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dam gave way and water levels in the creek rose by 2 to 3 metres.

7:15 PM — Dwayne Manchak was informed of the dam breakage, the damage that had occurred, work that was ongoing, and potential problems.

8:30 PM — Dwayne reached Al McMillan and informed him of the events. Al McMIllan called Doug Tupper, Vern Head, Bill Kuhnke, Darlene Dickinson, Barry Hurndall, and Terry Winhold. He reached Kuhnke, Hurndall and Dickinson (11:00 PM). Barry Hurndall agreed to inform Peter Melnychuk of the dam failure.

10:30 PM — Alberta Environment staff left Canmore.

Alberta Environment Involvement with Cougar Creek Situation May 26 - 28:

May 26 (Saturday)

10:30 AM — Ron Deeprose (Director of Technical Services Division) was contacted by Bob Kuzminski (Alberta Public Safety Services). Mr. Kuzminski requested that Alberta Environment personnel be on site during clean up operations.

11:00 AM — Terry Winhold (River Engineering Branch) contacted Bob Kuzminski for further details and to advise that arrangements were being made for River Engineering Branch personnel from Edmonton to travel to site as soon as possible. Al McMillan (Regional Administrator) and Ron Deeprose were later advised.

1:30 PM — Terry Winhold contacted Bob Kuzminski to advise that a Senior Technologist would be arriving on site sometime after 7:00 PM.

8:30 PM — Kelvin Dykema (River Engineering Branch) arrives at Cougar Creek. Contact is made with Bob Kuzminski and Frank Kosa (Manager, Town of Canmore).

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May 27 (Sunday):

9:00 AM — Meeting was held to discuss situation and formulate a plan for continuing clean up operation (i.e. sediment removal and repairs to crossings etc). This meeting was attended by Kelvin Dykema (River Engineering Branch) and Kent Berg (Calgary Region).

10:45 AM — Helicopter inspection was arranged by Alberta Public Safety Services.

May 28 (Monday):

9:30 PM — Kelvin Dykema (River Engineering Branch) re-visited the site. Observed that culverts through the CPR crossing had been cleared of sediment and was advised that the HWY 1A culverts would be cleared the following day.

SUMMARY OF DOWNSTREAM DAMAGES

- CPR rail grade was breached and culverts blocked
- HWY 1A was overtopped and culverts blocked
- Severe bank erosion along Cougar Creek

RECOMMENDED FUTURE ACTION

Studies should be initiated to:

1. Assess the cause for the dam failure (i.e., design deficiency or design flood exceeded).
2. Assess the need to reconstruct the dam and sediment trap.
3. Evaluate other alternatives.

DS Photo No. 9069-B20

Friday, May 25, 1990.
1 hour before failure.

DS Photo No. 9069-B18

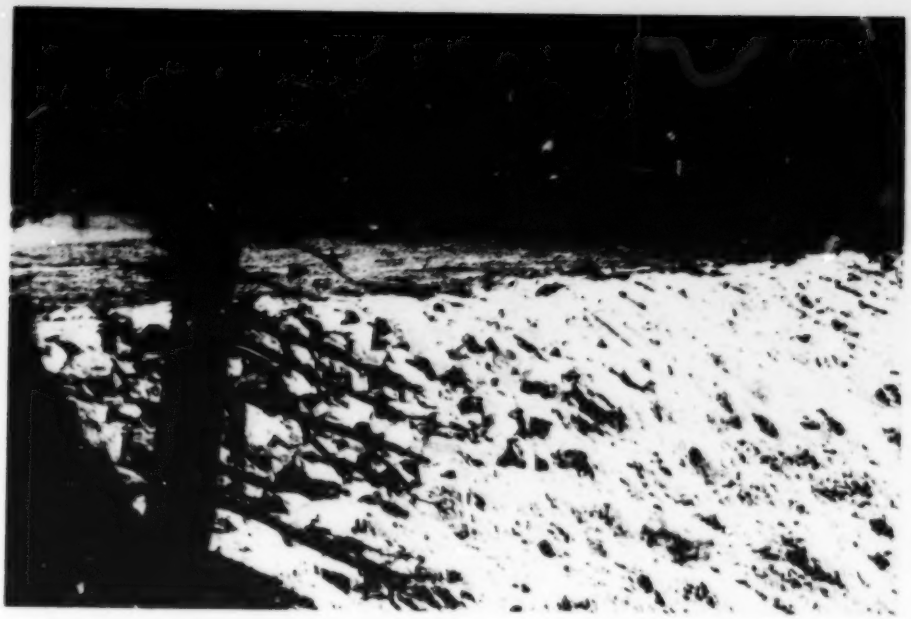
Friday, May 25, 1990.
10 minutes before failure.

DS Photo No. 9069-C10

Taken by and reproduced with the permission of
Ingo W. Kalk - "Photographic Images" - Canmore, Alberta.

DS Photo No. 9069-B21

Friday, May 25, 1990.
5 minutes before failure.



DS Photo No. 9069-C9

Taken by and reproduced with the permission of
Ingo W. Kalk - "Photographic Images" - Canmore, Alberta.
Approximately 5:15 p.m. Friday, May 25, 1990.
Downstream slope armouring beginning to shift.

DS Photo No. 9069-C8

Taken by and reproduced with the permission of
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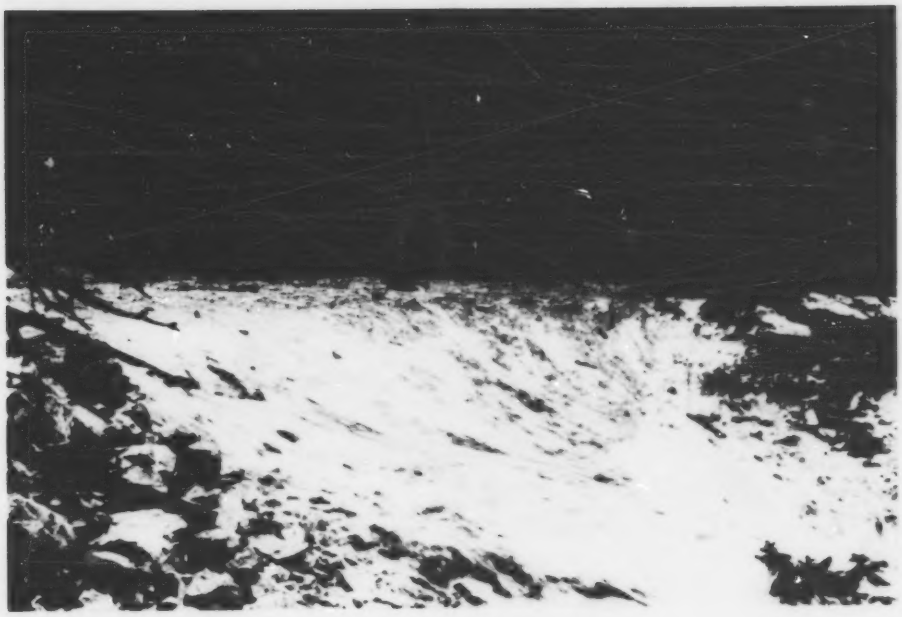
Approximately 5:18 p.m. Armouring on crest being displaced.
Beginning of breach.



DS Photo No. 9069-C7

Photo taken and reproduced with permission of
Ingo W. Kalk - "Photographic Images" - Canmore, Alberta.
Breach is widening and progressing upstream.

DS Photo No. 9069-B22

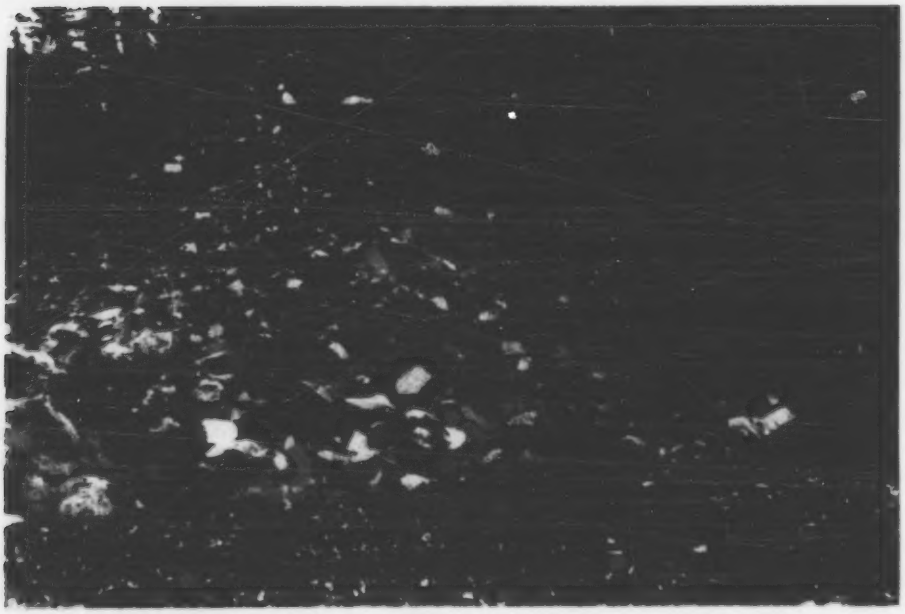
DS Photo 9069-B23
Approximately 1 min. after failure

DS Photo 9069-C6

Photo taken and reproduced with the permission of
Ingo W. Kalk - "Photographic Images" - Canmore, Alberta.
Approximately 45 minutes after failure.
Note water elevation.

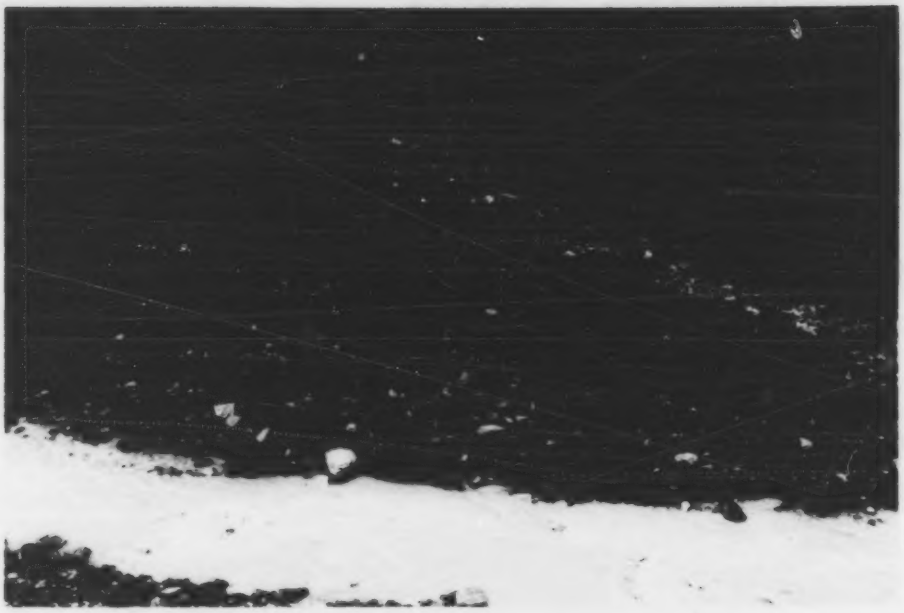
DS Photo 9069-B27

Friday, May 25, 1990.
Approximately 2 hours after failure.
Note water elevation.



DS Photo 9069-B4

Note blanket of silt on remaining
upstream left abutment.



DS Photo No. 9014-4

Side view of remaining left abutment.

DS Photo No. 9048-10A

Looking downstream from reservoir through breach.
Note terraces on left side.

DS Photo 9069-B26

Aerial view of erosional damage to armoured channel downstream of the sediment trap.

Kananaskis Country

OPERATIONS BRANCH
Box 280, CANMORE, ALBERTA, CANADA T0L 0M0 (403) 678-5508

November 06, 1990

Dick Allison
Technical Services Division
Alberta Environment
Provincial Building
Room 2118
200, 5th Avenue S.
Lethbridge, Alberta
T1J 4L1

Dear Dick;

I have put together an information package concerning the Cougar Creek flooding in May of 1990. Could you please send this information along to the appropriate person you are dealing with in Edmonton. I would also like to add the following points which I feel led up to the collapse of the dam at the head of Cougar Creek subdivision. The following points are:

1. On May 16, 1990, 10 days before the dam burst, the Kananaskis Country Rangers were in the area. They were at the scene in the photographs taken from the helicopter doing a heli-sling rescue practice. At that time it was noticed that the average snow pack depth was 1 m deep throughout the majority of the area.

2. The rainfall precipitation information from the Banff Weather Station is as follows:

RECEIVED WATER RESOURCES ADM
DAM SAFETY BRANCH
NOV 15 1990

May 15 - 1.4 mm
May 16 - 0.0 mm
May 17 - 0.2 mm
May 18 - 3.8 mm
May 19 - 1.0 mm
May 20 - 5.6 mm
May 21 - 0.2 mm
May 22 - 0.0 mm
May 23 - trace
May 24 - 21.8 mm
May 25 - 29.6 mm (the day the dam broke)

3. Mr. Ingo Kalk, who is a professional photographer,

CIRCULATE TO
ANDERSON
CHEUNG
FROELICH
[illegible]
[illegible]
[illegible]
[illegible]
LIVINGSTONE
[illegible]
McEWEN
NOWOSIAD
FILE

Kananaskis Country

supplied dam site photographs, times of water levels rising, and the dam burst. He was at that location 1 hr. previous to the dam bursting. He had noticed that the water was flooding over the dam at a regular state which was also reported by various other people 2 to 3 days previous to the dam burst. While Ingo was at the site taking photographs, he noticed that the water level begin to increase at a substantial rate. This was evidenced by a particular rock which was moved from a stationary position to large rattling of movement , and then to be washed away just before the dam burst over its top. Ingo subsequently took photographs of this whole situation.

4. It is my belief that the avalanche shown on Map A which is a 1:50,000 scale and in enlarged area on Map B was subsequential to the immediate raising of the water level within the hour that Ingo was present at the dam. The calculation for the area of the water would be easy to extrapolate from the information but a raise of water for at least a 1/2 m to add that kind of pressure to wash the dam completely out would have to be some kind of insurgence of extra water with a force behind it. The dam had remained stable and was holding a full volume of water behind it and not showing any signs of breaking for at least 3 to 5 days before the burst.

5. To replace the dam as the similar rock wall would invite this situation to develop again. The building of a new type of dam is probably costly but something with a controllable spillway would probably be more prudent. The working of the creekbed with some kind of ditch formation of cement slabs would also be costly and may have the inherent problem of being eroded from behind which would add to the problem of the control.

Therefore, in conclusion, I feel from the evidence presented by the persons taking the photographs and from talking to local people that the avalanche had an large effect on the dam being unable to contain the water. I feel that this situation could happen again without the construction of a proper dam at the same location. This situation has not only the need to be looked at from an engineering/construction point of view, but also from a public safety point of view with regards to a housing development at Cougar Creek and the inquiring mind of the public who are brought to these locations during times of extreme hazard. Thank you for your time to review this

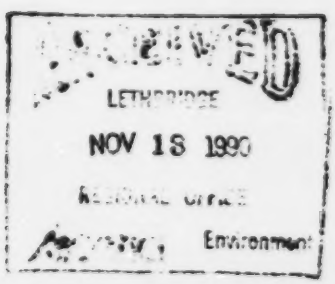
Kananaskis Country

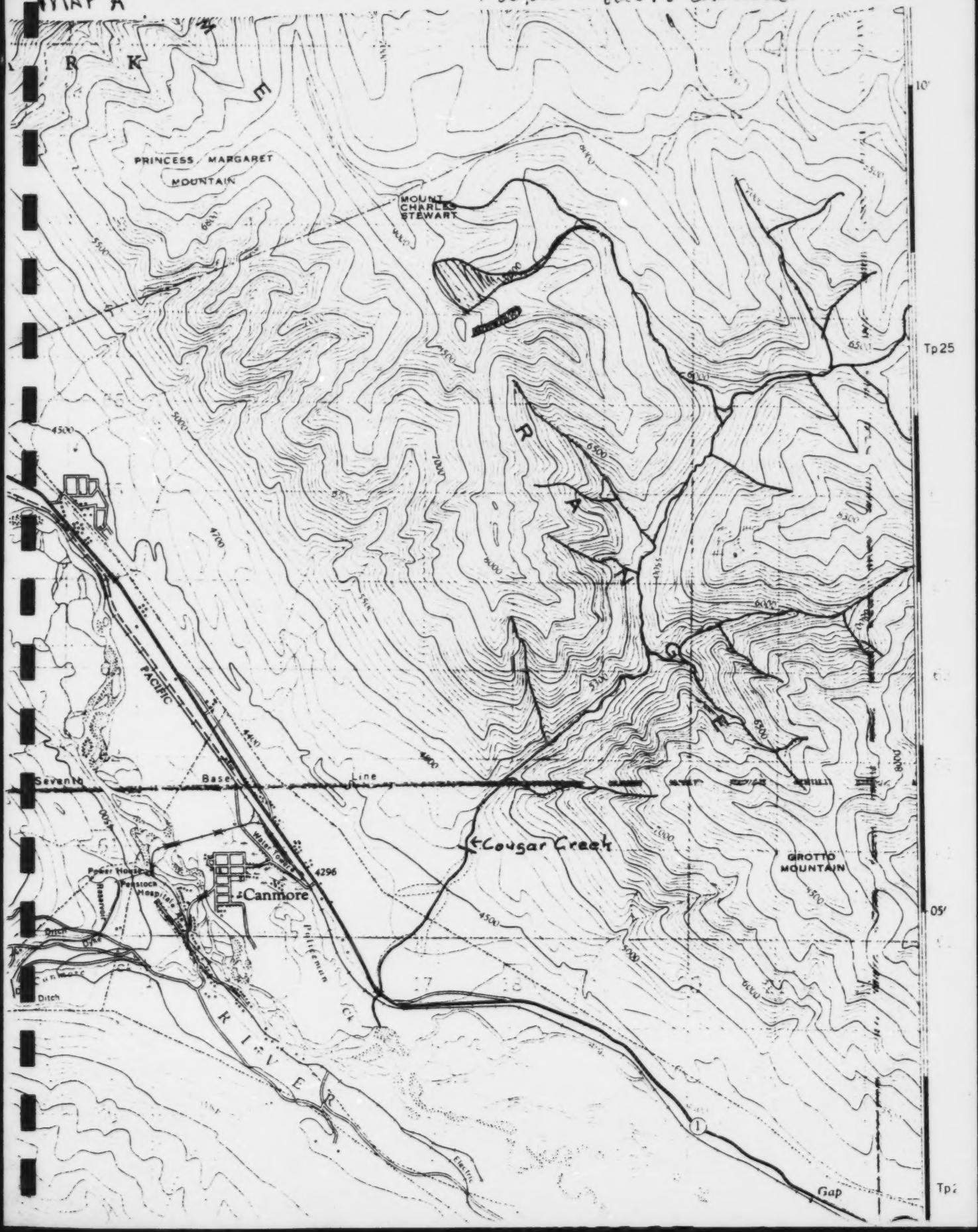
information, and I hope to hear from you and the Edmonton office as to the conclusion that they have reached concerning this catastrophe. Thank you very much.

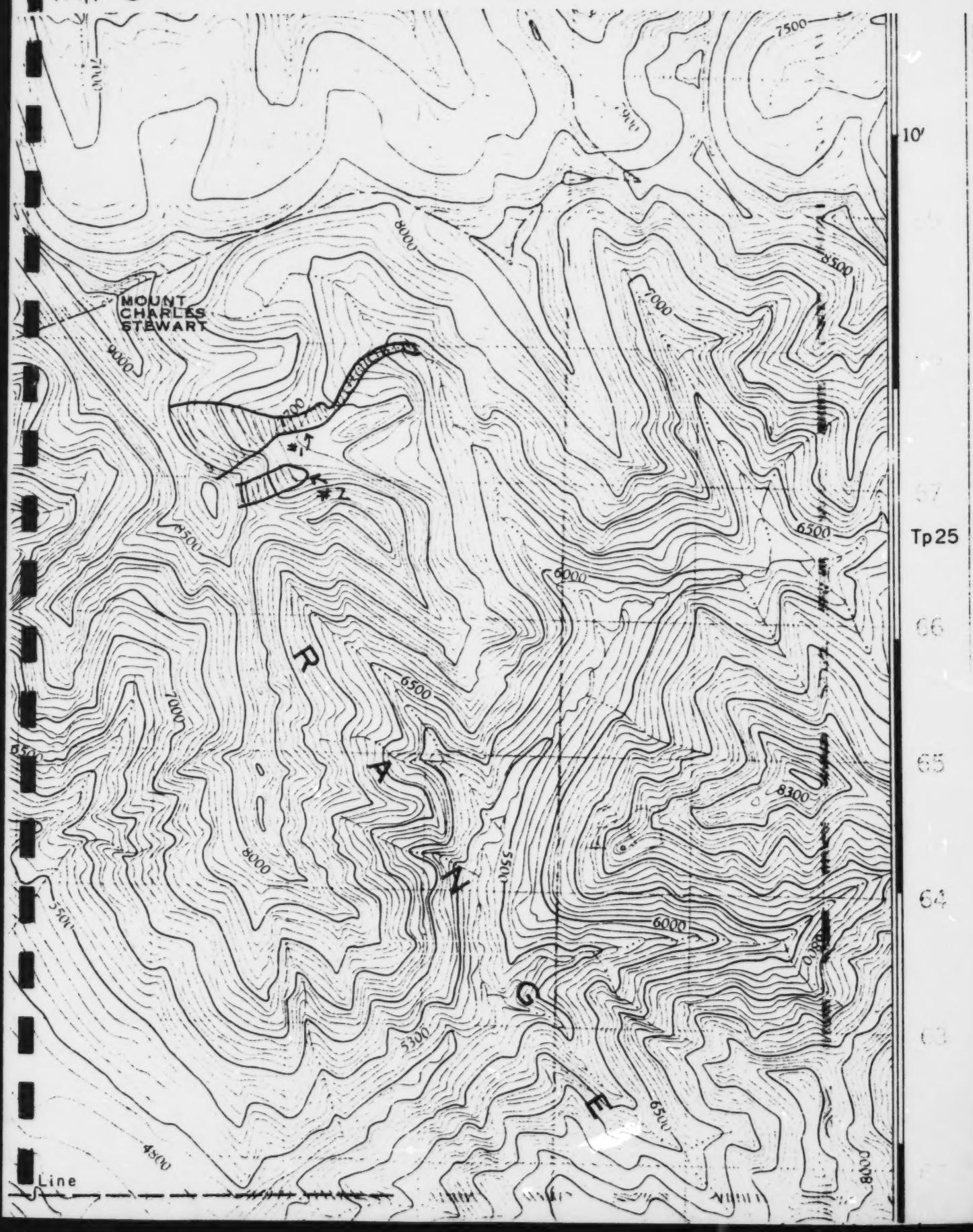
Yours truly,

George Field
Alpine Specialist
Kananaskis Country

GF/rm




MAP A
1:50,000 82 C/3 CANMORE
PRINCESS MARGARET MOUNTAIN
MOUNT CHARLES STEWART
PACIFIC
Seventh Base Line
Cougar Creek
GROTTO MOUNTAIN
Canmore
Power House
Penstock
Reservoir
Ditch
Pigeon Mtn
Gap
Tp25
05'


MAP B
MOUNT CHARLES STEWART
RANGE
Tp25
Line

DS Photo No. 9069-A3

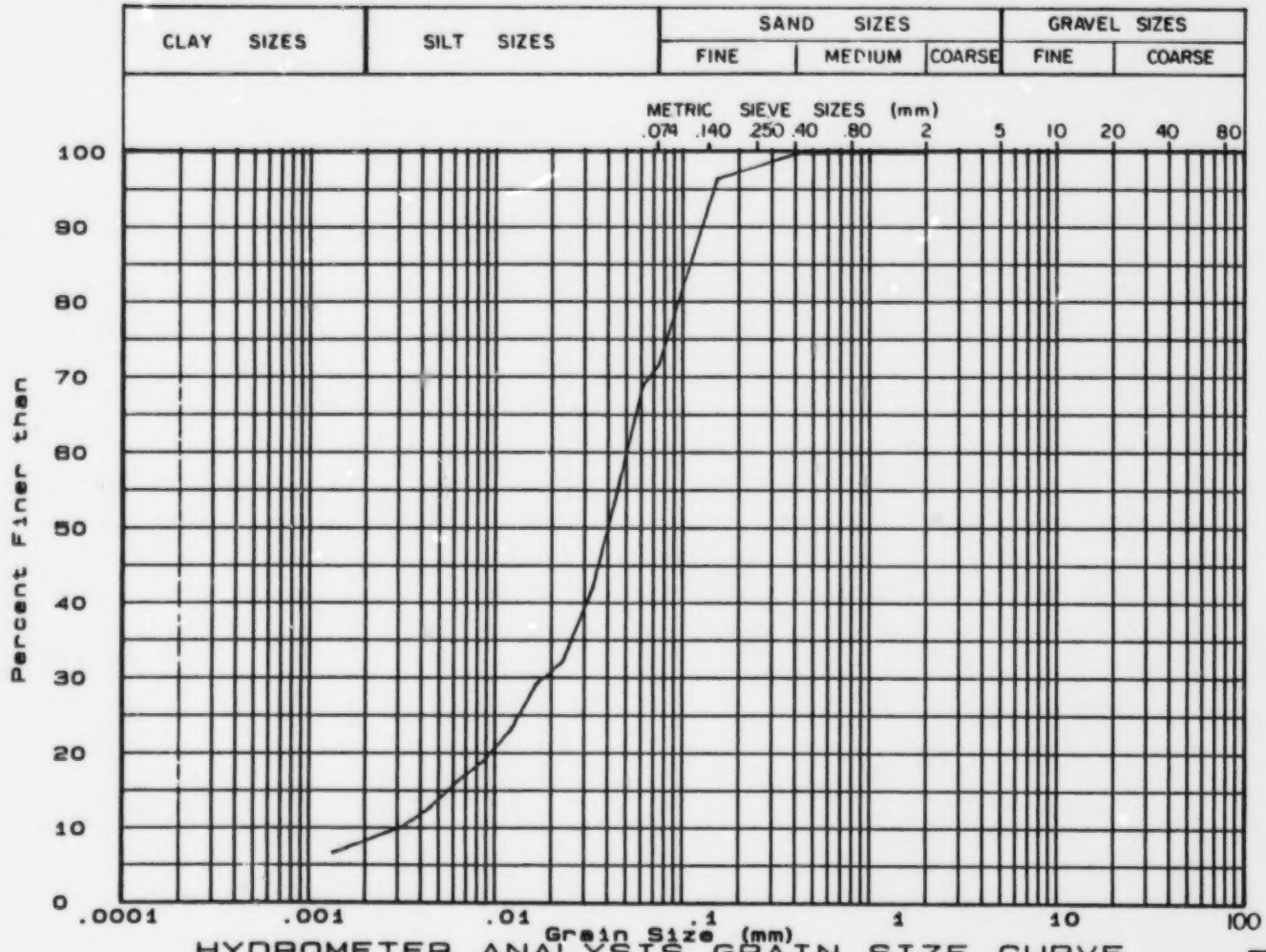
DS Photo No. 9069-A4

DS Photo No. 9069-A2

DS Photo No. 9069-A1

Silt blanket overlaying upstream slope
Taken from left abutment.

GS-101-86



HYDROMETER ANALYSIS GRAIN SIZE CURVE

HYDROMETER DATA	
DIA. (mm)	% FINER THAN
2.0000	100.0
.4000	99.8
.1500	96.4
.0740	71.8
.0605	68.8
.0450	55.4
.0333	42.2
.0232	32.3
.0166	29.1
.0123	23.4
.0088	19.2
.0063	16.3
.0045	12.8
.0032	10.2
.0014	6.7

GRAVEL	%
SAND	%
SILT	%
CLAY	%

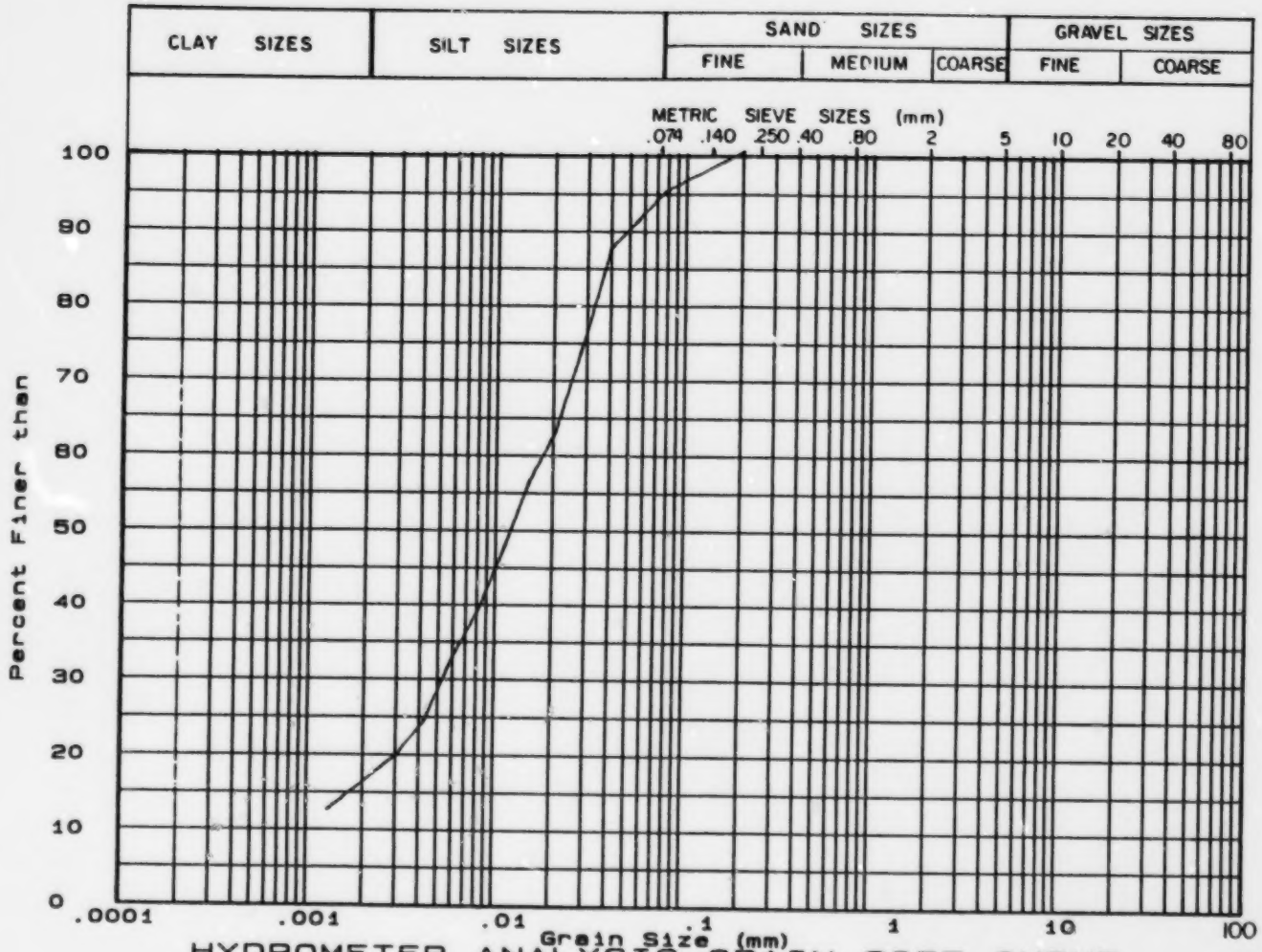
SAMPLE NO.	LOCATION	DEPTH (m)	CLASSIFICATION	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	Cu	Cc	% <.074 mm
1				0.003	0.019	0.05	16.67	2.41	71.8

Alberta
ENVIRONMENT
DEVELOPMENT & OPERATIONS DIVISION
GEOTECHNICAL SERVICES LABORATORY

COUGAR CREEK
1
22 Aug 1990

Sample taken from exposed silt layer
in reservoir approx. 30 metres
upstream of sediment trap on left side.

GS-101-86



HYDROMETER ANALYSIS GRAIN SIZE CURVE

HYDROMETER DATA	
DIA. (mm)	% FINER THAN
.2000	100.0
.0765	94.7
.0551	90.8
.0397	87.0
.0295	75.1
.0208	62.6
.0151	55.8
.0114	47.5
.0083	38.8
.0060	32.1
.0044	24.1
.0031	19.6
.0013	12.2

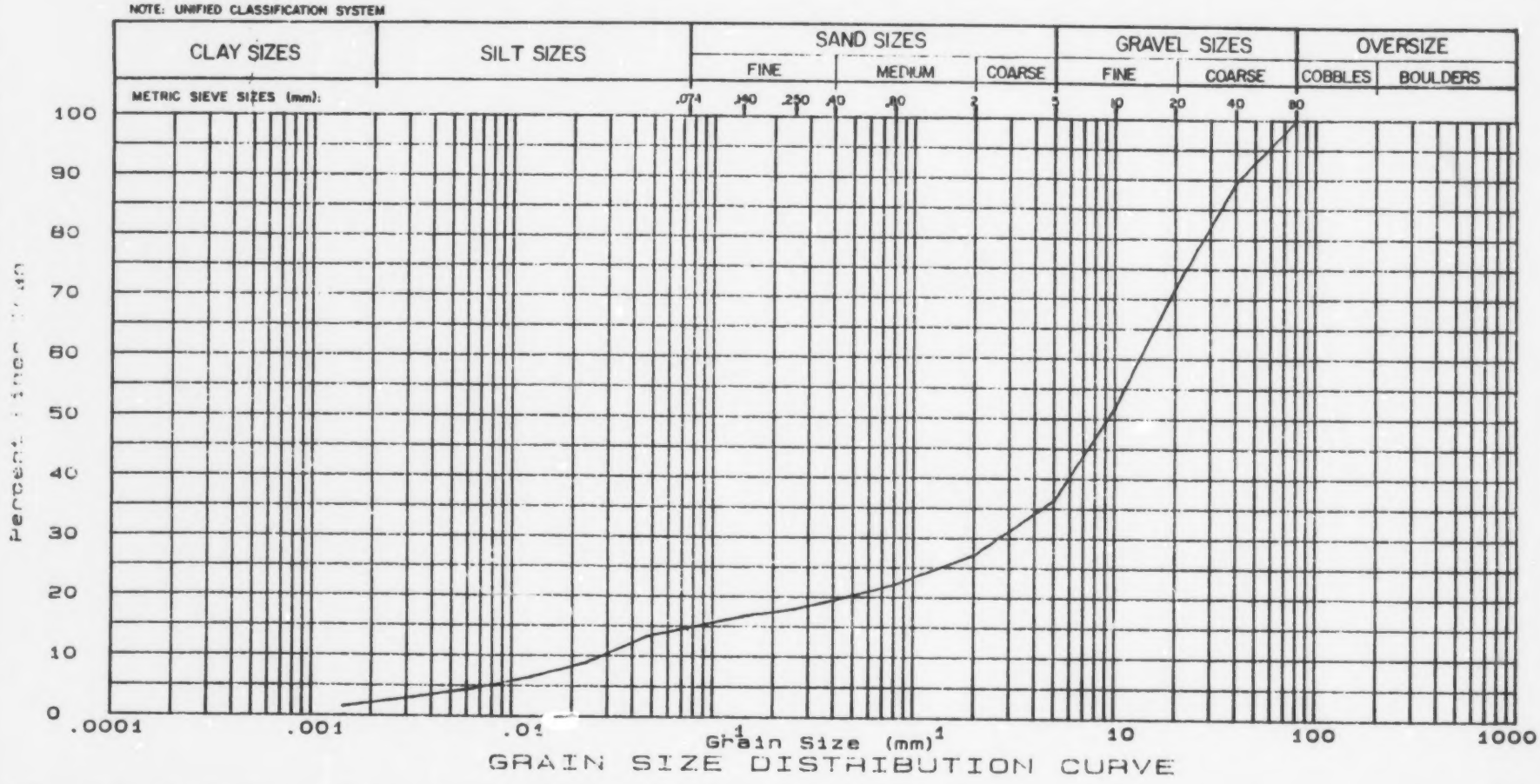
GRAVEL	%
SAND	%
SILT	%
CLAY	%

SAMPLE NO.	LOCATION	DEPTH (m)	CLASSIFICATION	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	Cu	Cc	% <.074 mm
2				—	0.0052	0.018			95

Alberta
ENVIRONMENT
DEVELOPMENT & OPERATIONS DIVISION
GEOTECHNICAL SERVICES LABORATORY

COUGAR CREEK
2
22 Aug 1990

Fines taken from core material ½ way up breach on left abutment.



GRAIN SIZE DISTRIBUTION CURVE

SAMPLE No.	CLASSIFICATION	LOCATION	DEPTH	D_{10}(mm)	D_{30}(mm)	D_{60}(mm)	C_u	C_c	%< .074
3				0.029	2.5	13	44828	16.58	14.5

Alberta ENVIRONMENT

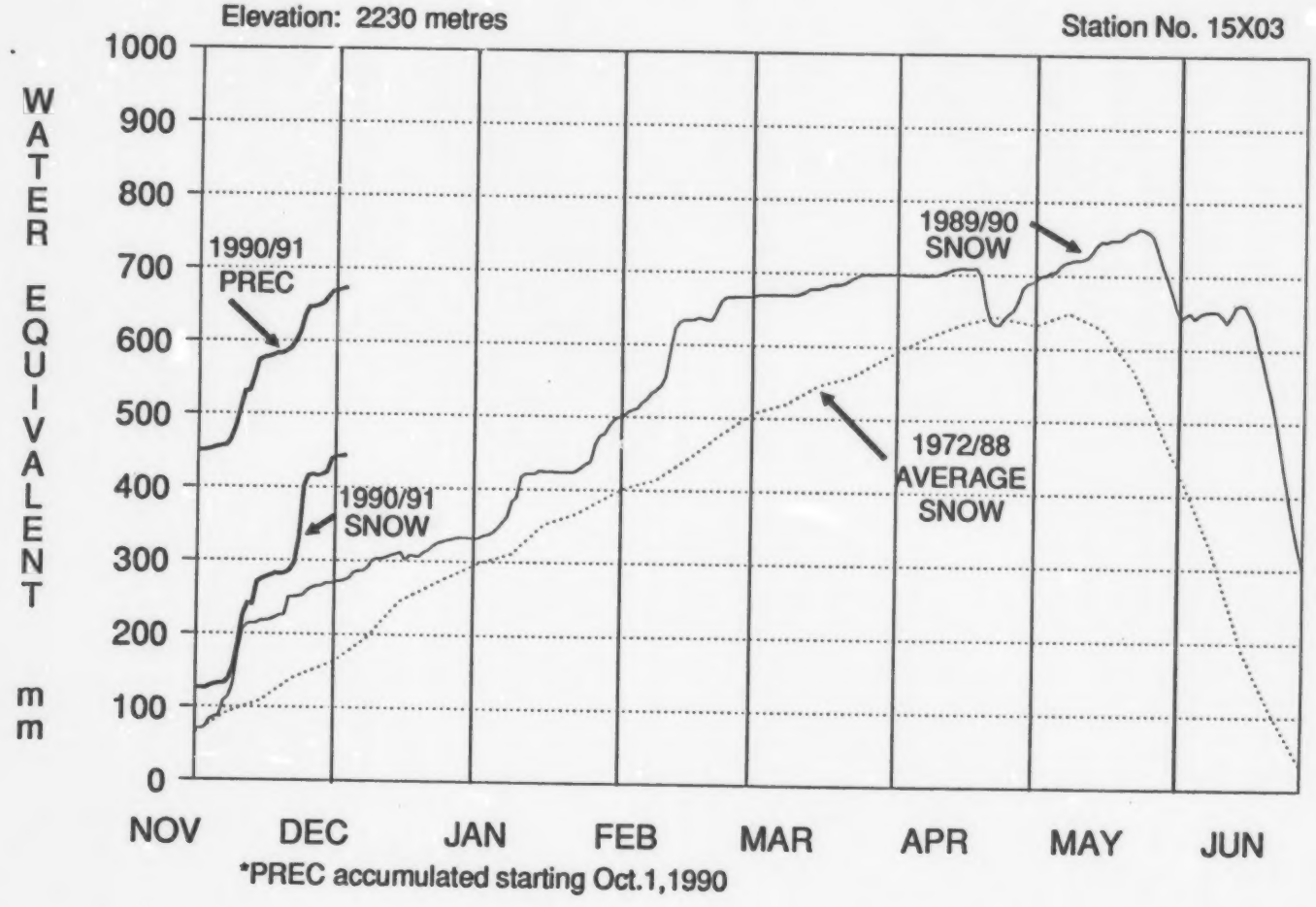
DESIGN AND CONSTRUCTION DIVISION
GEOTECHNICAL BRANCH

COUGAR CREEK

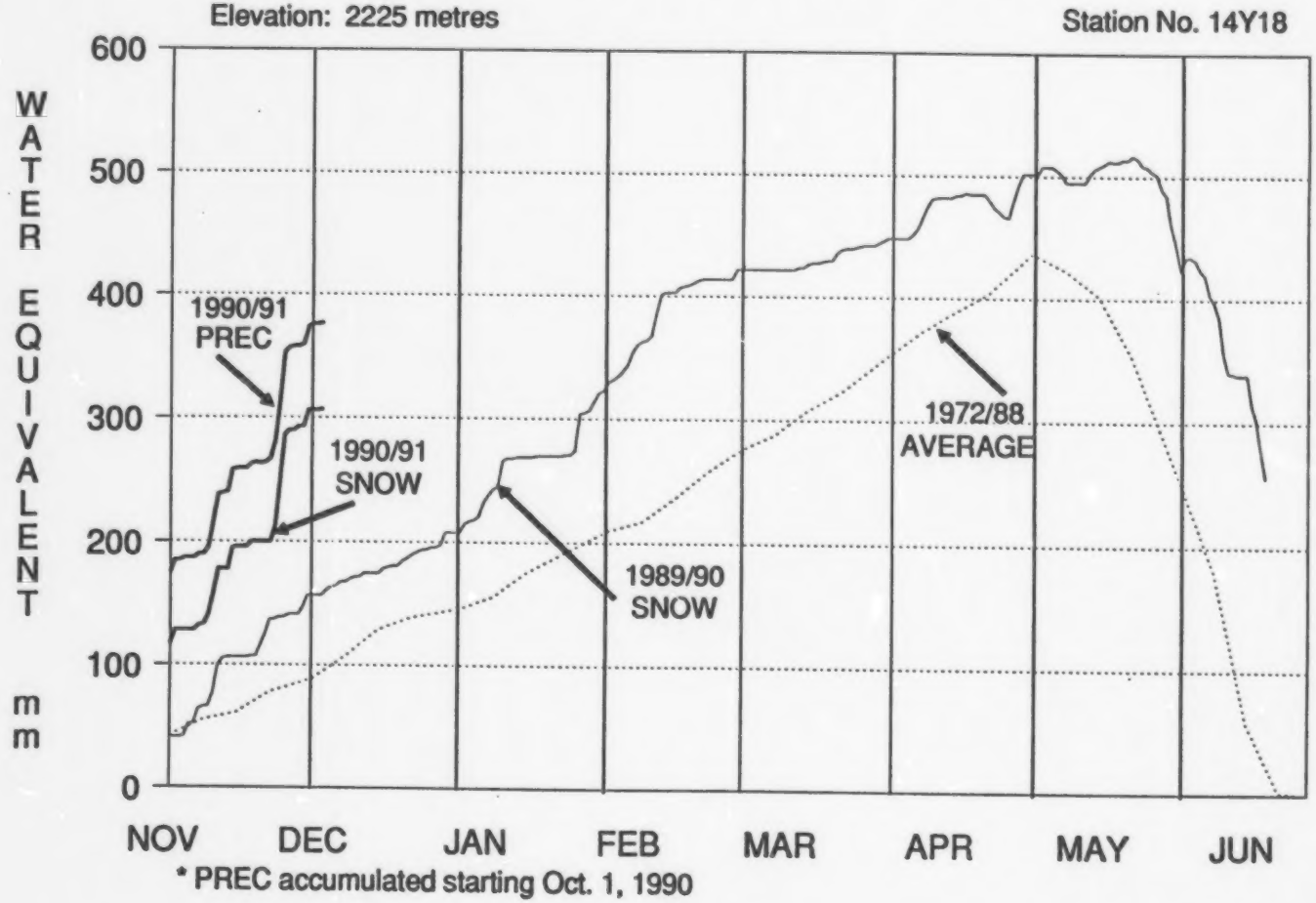
3

23 Aug 1990

SUNSHINE VILLAGE SNOW PILLOW
BOW RIVER HEADWATERS



LITTLE ELBOW SUMMIT SNOW PILLOW
ELBOW RIVER HEADWATERS



MAPS
NOT
FILMED

CARTES
OMISES